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SUMMARY

Landing-contact conditions for 71 landings of the XB-70 airplanes are analyzed. Some of the conditions are similar to those that may be experienced by future supersonic vehicles.

Results are presented as frequency histograms and cumulative frequency distributions in terms of probability. The landing-contact parameters examined include vertical velocity; indicated airspeed; angles of roll, pitch, attack, and sideslip; and rolling and pitching velocities.

INTRODUCTION

In recent years several statistical studies have been made to determine the landing-contact characteristics of commercial turbojet transports (refs. 1 to 4). These studies are useful in ascertaining limitations on the operation of airplanes on existing runways, in the design of new runways, in the design of airplanes, and to some extent in the overall safety of flight operations. Currently, knowledge of landing-contact conditions for a new generation of supersonic-cruise vehicles is required in order to evaluate future specifications in these areas. However, only a limited number of aircraft can provide such information. The size, weight, and inertia characteristics of the XB-70 make it of interest in this regard. Thus, a study of XB-70 landing-contact characteristics was conducted, and the data obtained were analyzed statistically. The results of this analysis are presented in this paper. Touchdown parameters examined were vertical velocity; indicated airspeed; angles of roll, pitch, attack, and sideslip; and rolling and pitching velocities. Data were obtained from landings of the XB-70-1 and XB-70-2 airplanes following flights from Edwards Air Force Base, Calif.

Measurements for this investigation were taken in U.S. Customary Units. Equivalent values in the International System of Units (SI) are presented herein in the interest of promoting use of this system in future NASA reports. Details of SI, together with physical constants and conversion factors, are given in reference 5.

DESCRIPTION OF THE AIRPLANE

The XB-70 airplane (fig. 1) is described in detail in reference 6. Briefly, the airplane has a design gross weight in excess of 226,795 kilograms (500,000 pounds) and a design cruise Mach number of 3.0 at altitudes of 21,336 meters to 24,336 meters (70,000 feet to 80,000 feet). It has a thin, low-aspect-ratio, 65.6° swept leading-edge delta wing with folding tips, twin movable vertical stabilizers, elevon surfaces for pitch and roll control, and a movable canard with trailing-edge flaps. The flight control system is irreversible.

Propulsion is provided by six YJ93-GE-3 engines; each engine develops a maximum thrust of 12,701 kilograms (28,000 pounds), with full afterburner, at sea level. The six engines are mounted side by side at the rear of the fuselage in a single nacelle under the center section of the wing. The nacelle is divided into twin, two-dimensional, mixed-compression inlets incorporating variable throat wall positions and adjustable bypass airflow doors for optimum operation throughout the Mach number range.

INSTRUMENTATION AND DATA REDUCTION

Parameters pertinent to this investigation, the type of sensors used, and the range of measurement, type of recording, frequency response, and accuracy of the sensors are presented in the following table:

Parameter	Sensor type (1)	Range	Recording system and frequency response		Accuracy, percent of full range
			Digital, cps	Analog, cps	
Nose boom angle of attack	A	-10° to 30°	4.0	2.5 25	0.8
Nose boom angle of sideslip	A	±20°	4.0	2.0 20	0.8
Roll angle at center of gravity	B	±45°	4.0	---	2.0
Pitching velocity at center of gravity	C	±10 deg/sec	4.0	---	2.0
Rolling velocity at center of gravity	C	±100 deg/sec	4.0	---	2.0
Airspeed (coarse)	D	50 to 800 knots	0.8	---	2.0
Airspeed (fine)	D	70 knots per revolution	0.8	---	2.0
Trailing-arm position	E	0 to 12 inches	---	35	2.5

[1]A - Angle of attack and sideslip sensor with linear variable differential transformer.
B - Attitude gyro with 2 K potentiometer pickoff.
C - Rate gyro with microsyn pickoff.
D - 2 K potentiometer pickoff.
E - Position transmitter with strain-gage bend beam.

Data were recorded on the XB-70 internal recording system.

Instruments installed in environmentally controlled areas were calibrated at ambient temperatures. Where in-flight elevated temperatures were anticipated, calibrations were made at a sufficient number of temperature conditions to determine the error caused by temperature change.

Data were recorded on magnetic tape using digital techniques. The digital recordings consisted of static or quasi-static data, where frequency response requirements were low. Each parameter was sequentially sampled and recorded on magnetic tape in 10-bit parallel binary form. The channel capacity of the recording equipment was 706 parameters. Recording time was 64 minutes, with a tape-packing density of 666 data words per linear inch of tape.

The airborne digital-data tape was reduced by first editing to select the desired parameters and time periods for analysis. The time-edited data were converted from the flight-recorded format to engineering units, and calibrations were applied. The data were then tabulated or plotted as required. All data-reduction was done on automatic data-processing equipment.

Analog recordings used standard IRIG frequency-modulation techniques for recording on magnetic tape. A magnetic-tape speed of 0.381 meter per second (15 inches per second) was used. The overall error of data recorded on tape was approximately ±3 percent of full scale, including data-sensor and transmission-lead error. The analog data were reduced by feeding the flight data into a playback tape transport which divides a single track into 12 signals. The signals were then fed into a discriminator bank, the output of which could be digitized. The signals were corrected and scaled before being reproduced on oscillograph recorders or a direct-writer recorder.

Values of the pitch angle measured at the center of gravity during touchdown were considered to be unreliable because of errors in the transducer caused by longitudinal acceleration. However, pitch angle was calculated for the XB-70-1 when vertical velocity was available by using the expression $\Theta = \alpha - \gamma$, where Θ = pitch angle, α = angle of attack, and γ = arc sin of vertical velocity divided by velocity at touchdown.

The vertical-velocity data were obtained from the XB-70-1 airplane by using mechanical probes mounted on all three gears and electrical position transducers. The probe mechanism (fig. 2) consists of a trailing arm which is free to rotate about a pivot point on the lower extremities of each shock strut. In the landing position, the trailing arms are extended aft and downward so that the ground contact shoe is in a stationary position approximately 0.305 meter (1 foot) below the tires. At landing, the arms make initial contact with the ground and as the airplane descends the arm is forced to retract. The position transducer senses the arm position, which is directly related to the height of the wheel from the ground, once the arm has made contact. These data, when recorded as a function of time, provide an accurate measurement of vertical velocity of the aft truck at touchdown for each gear. (Hereafter, "vertical velocity" is used to denote the vertical velocity of the aft truck, as measured by the trailing arms.)

The moment at which the aft truck of the first main gear touched the ground was selected as the time of touchdown. This time could be determined precisely for the XB-70-1 by using data obtained from the instrumented main-gear system. The touchdown time for the XB-70-2 could only be approximated because the left main gear, fifth wheel, brake reference system was the only gear instrumentation available. By using the fifth wheel spin-up and the accelerometer at the center of gravity, a touchdown time within 0.2 second to 0.5 second was estimated. It was not possible to determine which gear contacted the ground first.

LANDING-CONTACT CONDITIONS

Landing-contact conditions for 71 landings of the XB-70 airplanes are summarized in table I. Omissions in the table are the result of system failures, instrumentation malfunctions, or emergency conditions. The landings were made by four pilots, two from North American Aviation, Inc., and two from the U.S. Air Force. Each pilot had considerable flight research experience with large jet aircraft. Although the pilots were aware that landing data were being obtained, no special techniques, speeds, or other restrictions were requested, nor were any flights made solely to obtain landing data.

All of the landings except two were made on the 4,572-meter (15,000-foot) concrete runway at Edwards Air Force Base. The landings on XB-70-1 flights 2 and 13 were made on Rogers Dry Lake at Edwards, Calif.

The glide slope for landing was approximately 1.5°, in contrast to a normal instrument landing system approach of 2.5° to 3.0°. In addition, on many of the landings the XB-70 pilots were given altitude cues by escort pilots before landing contact.

RESULTS AND DISCUSSION

The landing-contact parameters analyzed were vertical velocity; indicated airspeed; angles of roll, pitch, attack, and sideslip; and rolling and pitching velocities (see table I). In general, landing weight ranged from 125,871 kilograms (277,500 pounds) to 190,418 kilograms (419,800 pounds), and airspeed varied from 154.9 knots to 195.0 knots. The vertical velocity at touchdown ranged from 0.455 meter per second (1.49 feet per second) to 1.603 meters per second (5.26 feet per second).

The landing data were analyzed statistically by computing the statistical mean, variance, third moment, standard deviation, coefficient of skewness, and cumulative frequencies for each pertinent parameter. The pertinent statistical parameters and the maximum measured quantities are summarized in the following table:

Parameter	Mean	Maximum	Standard deviation	Coefficient of skewness
Vertical velocity	1.02 m/sec (3.35 ft/sec)	1.603 m/sec (5.26 ft/sec)	0.296 m/sec (0.971 ft/sec)	-0.137
Airspeed[1]	171.4 knots	187.0 knots	7.620 knots	-0.234
Absolute angle of roll	1.37°	3.9°	0.938°	0.552
Angle of pitch	8.56°	9.9°	0.640°	0.573
Angle of attack	8.91°	10.59°	0.912°	-0.899
Absolute angle of sideslip	0.82°	-4.2°	0.796°	2.007
Absolute rolling velocity	1.16 deg/sec	6.23 deg/sec	1.243 deg/sec	1.993
Absolute pitching velocity	0.35 deg/sec	-1.32 deg/sec	0.296 deg/sec	1.075

[1]Airspeed adjusted to a constant weight (see discussion on page 5).

Generally, two plots are presented in this paper for each parameter analyzed: a frequency histogram and a cumulative frequency distribution in terms of probability. A Pearson Type III probability curve is included in the cumulative frequency plots. The Pearson Type III curves provide a systematic fairing of the data and permit some extrapolation in order to give an indication of the magnitude of the various quantities likely to be equaled or exceeded in a greater number of landings than were actually observed. Details of the computation process are given in the appendix.

Vertical Velocity

Figure 3 shows the frequency distribution of vertical velocity at touchdown for 26 landings in percent of landings occurring in class intervals of 0.15 meter per second (0.49 feet per second). For the greatest number of landings, 23.1 percent, the vertical velocity was in the intervals of 1.05 meters per second to 1.20 meters per second (3.44 feet per second to 3.94 feet per second), whereas on only 3.8 percent of the landings a vertical velocity of 1.50 meters per second to 1.65 meters per second (4.92 feet per second to 5.41 feet per second) was attained. The mean vertical velocity for the recorded landings was 1.02 meters per second (3.35 feet per second).

Figure 4 shows the probability of equaling or exceeding given values of vertical velocity. The vertical velocity at a probability of 0.01 is 1.69 meters per second (5.54 feet per second), which is the rate of descent that will probably be equaled or exceeded once in every 100 landings. A probability of 0.01 was selected because it represented a probability, in view of the limited number of samples, that required little extrapolation of the data sample.

As a result of the factors discussed in the section on landing-contact conditions, the measured vertical velocities may be somewhat lower than those of landings that would take place on a commercial airport runway.

Airspeed

Calculated touchdown velocities, determined by adjusting the measured touchdown velocity at the actual weight at contact (variable from flight to flight) to the design landing weight of 128,365 kilograms (283,000 pounds), are noted in table I. The frequency distribution of the adjusted airspeeds at touchdown, with the effect of variations in weight removed, are presented in figure 5 in class intervals of 5 knots. The greatest number of landings, 24.6 percent, occurred in the interval of 175 knots to 180 knots, while 1.5 percent of the landings were made at the extreme intervals of 185 knots to 190 knots and 150 knots to 155 knots. The mean airspeed was 171.4 knots. The probability distribution of the airspeed (fig. 6) shows that 1 landing in 100 would be likely to equal or exceed 187.5 knots. It should be emphasized that the high airspeeds at landing result from the experimental and military nature of the aircraft, as discussed in the section on LANDING CONTACT CONDITIONS.

Angle of Roll

The frequency distribution of angle of roll at landing contact for 64 landings is presented in figure 7. The values range from -3° to 4°.

The frequency distribution of the absolute roll angle at touchdown (fig. 8) shows that the greatest percentage of landings (25.0) occurred in the interval from 0° to 0.5°. The mean absolute roll angle was 1.37°. The probability distribution of roll angle (fig. 9) indicates that 1 landing in 100 would be likely to equal or exceed 3.92°.

Angle of Pitch

Figure 10 shows the frequency distribution of the angle of pitch at touchdown for 21 landings in percent of landings occurring in class intervals of 0.4°. For the greatest number of landings, 38.1 percent, the pitch angle was in the interval of 8.0° to 8.4°. The mean pitch angle for 21 landings was 8.56°. Figure 11 shows the probability of equaling or exceeding given values of pitch angle. The probability distribution indicates that 1 landing in 100 would be likely to equal or exceed 10.2°.

In the XB-70 airplane the pilot is 32.3 meters (106 feet) ahead of the main gear and approximately 11.6 meters (38 feet) in the air at the time of main-gear contact for a landing at an angle of attack of 10°. These distances are nearly twice as great as those of present-day subsonic jet airplanes. However, the location of the pilot at main-gear contact has little detrimental effect on height judgment, as shown in figure 12. Although the results show some scatter, a trend of increasing vertical velocity with increasing pitch angle is not observed.

Angle of Attack

Figure 13, a frequency histogram of angle of attack at touchdown for 63 landings, shows that the greatest percentage of landings (30.2) occurred in the interval from 8.5° to 9.0°. The probability distribution of angle of attack in figure 14 indicates that 1 landing in 100 would be likely to equal or exceed 10.5°. The mean angle of attack was 8.91°.

Angle of Sideslip

A frequency histogram of angle of sideslip at touchdown for 63 landings (fig. 15) shows that the greatest number of landings, 28.6 percent, occurred between 0° to 0.5°, with values ranging between -4.5° and 3.5°. The frequency histogram of the absolute sideslip angle at touchdown in figure 16 shows that the greatest percentage of landings (49.2) occurred in the interval from 0° to 0.5°. The mean absolute angle of sideslip was 0.82°. The probability distribution of the absolute sideslip angle in figure 17 indicates that 1 landing in 100 would be likely to equal or exceed 3.72°.

Rolling Velocity

In references 1 to 4 a distinction is made in roll rate toward and away from the first wheel to touch down. Because this distinction could not be made on the XB-70-2 airplane, the absolute values of rolling velocity at touchdown for 60 landings of the XB-70-1 and XB-70-2 were used for computation. Figure 18 presents the frequency distribution of the absolute rolling velocities at landing contact. The values range from -3.5 degrees per second to 6.5 degrees per second.

The frequency distribution of the absolute rolling velocities in figure 19 indicates that 40.0 percent of the landings occurred with a rolling velocity between 0 and 0.5 degree per second. The mean absolute rolling velocity was 1.16 degrees per second. The probability distribution in figure 20 indicates that 1 landing in 100 would be expected to equal or exceed 5.7 degrees per second.

Pitching Velocity

Of the 59 landings on which pitching-velocity data were obtained, the airplane was pitching up at landing contact on 50.8 percent of the landings and pitching down on 49.2 percent. Figure 21 presents the frequency histograms of pitching velocity, up and down, at touchdown in percent of landings occurring in class intervals of 0.10 degree per second. The greatest number of pitch-up landings (13.6 percent) occurred in the interval of 0 to 0.10 degree per second; the highest number of pitch-down landings (11.9 percent) occurred in the interval of 0 to -0.10 degree per second. The frequency histogram for the absolute value of pitching velocity at touchdown is shown in figure 22. The probability distribution in figure 23 indicates that 1 landing in 100 would be expected to equal or exceed 1.25 degrees per second, pitch up or pitch down. The mean absolute pitching velocity was 0.35 degree per second.

SUMMARY OF RESULTS

The following results were obtained from a statistical analysis of landing-contact conditions for 71 landings of the XB-70 airplanes:

1. One landing in 100 would be expected to equal or exceed a value of vertical velocity of 1.69 meters per second (5.54 feet per second). The mean vertical velocity was 1.02 meters per second (3.35 feet per second).

2. An airspeed, adjusted to the XB-70 design landing weight, of 187.5 knots at touchdown would be likely to be equaled or exceeded once in 100 landings. The mean airspeed was 171.4 knots.

3. An angle of roll of 3.92° at touchdown would be likely to be equaled or exceeded once in 100 landings. The mean absolute roll angle was 1.37°.

4. One landing in 100 would occur at an angle of pitch of 10.2° or greater. The mean pitch angle was 8.56°.

5. An angle of attack of 10.5° would be likely to be equaled or exceeded once in 100 landings. The mean angle of attack was 8.91°.

6. One landing in 100 would be expected to equal or exceed an angle of sideslip of 3.72°. The mean absolute sideslip angle was 0.82°.

7. The probability distribution of rolling velocity indicates that 1 landing in 100 would be expected to equal or exceed 5.7 degrees per second. The mean absolute rolling velocity was 1.16 degrees per second.

8. Of the landings reported, the airplane was pitching up at landing contact on 50.8 percent and pitching down on 49.2 percent. The greatest number of landings, 13.6 percent, occurred in the class interval of 0 to 0.10 degree per second, pitch up. The mean absolute pitching velocity was 0.35 degree per second. One landing in 100 would be expected to equal or exceed 1.25 degrees per second, pitch up or pitch down.

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732-01-00-03-24

APPENDIX

DETERMINATION OF STATISTICAL PARAMETERS AND PEARSON TYPE III PROBABILITY CURVE

A detailed discussion of the Pearson Type III probability curve used in analyzing the data in this paper is presented in reference 7. The purpose of this appendix is simply to describe the mechanics of computing the Pearson Type III curve, which provides a consistent mechanical system of fairing data so that the results can be considered on a comparable basis.

The first step in computing the curve is to tabulate the individual measurements, determine the class interval, and calculate the frequency of occurrence for each interval.

Moments for grouped data are computed as follows:

If x_1, $x_2 \ldots x_k$ occur with frequencies f_1, $f_2 \ldots f_k$, respectively, the r^{th} moment $\overline{x}^r$ is defined by the expression

$$\overline{x}^r = \frac{\sum_{j=1}^{k} f_j x_j^r}{N} = \frac{\sum f x^r}{N}$$

where

$$N = \sum_{j=1}^{k} f_j = \sum f$$

The moment m_r for grouped data about the mean $\overline{x}$ is given by the equation

$$m_r = \frac{\sum_{j=1}^{k} f_j (x_j - \overline{x})^r}{N} = \frac{\sum f(x - \overline{x})^r}{N}$$

The moment m_r' for grouped data about any origin A is defined as

$$m_r' = \frac{\sum_{j=1}^{k} f_j (x_j - A)^r}{N} = \frac{\sum f(x - A)^r}{N}$$

The relations between moments m_r and moments about an arbitrary origin m_r' are as follows:

$$m_1' = \bar{x} - A$$

$$m_2 = m_2' - m_1'^2$$

$$m_3 = m_3' - 3m_1' m_2' + 2m_1'^3$$

By using the moments calculated in the preceding steps, the standard deviation S, moment coefficient of skewness α, and standard statistical unit t can be obtained by using the following expressions:

$$S = \sqrt{m_2}$$

$$\alpha = \frac{m_3}{S^3}$$

$$t = \frac{x_i - \bar{x}}{S}$$

The probability can be determined directly by using a probability chart for the Pearson Type III curve (see refs. 8 and 9). By entering the chart at the proper value of coefficient of skewness and standard statistical unit, the probability can be determined.

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TABLE I. – VALUES OF LANDING-CONTACT CONDITIONS AND OTHER PERTINENT DATA FOR LANDINGS OF THE XB-70 AIRPLANES

[XB-70-1]

Flight (1)	Landing weight, kg (lb)	Measured indicated airspeed, knots	Adjusted airspeed, knots	Vertical velocity, m/sec (ft/sec)	Angle of roll, deg	Angle of pitch, deg	Angle of attack, deg	Angle of sideslip, deg	Rolling velocity, deg/sec	Pitching velocity, deg/sec
1	139,389 (307,300)	186.0	178.5	----- ----	-----	----	9.66	1.35	1.24	0.05
2	155,128 (342,000)	192.2	174.8	----- ----	0.22	----	7.70	-.15	3.51	-.18
3	139,933 (308,500)	173.4	166.1	----- ----	-.75	----	9.02	.96	6.23	-1.32
4	136,713 (301,400)	167.3	162.1	----- ----	-----	----	-----	-----	-----	-----
5	133,900 (295,200)	179.5	175.7	1.271 (4.17)	1.23	8.06	8.84	.18	3.22	-.24
7	137,121 (302,300)	182.1	176.2	.491 (1.61)	1.62	8.04	8.34	.91	.47	-.22
9	190,418 (419,800)	195.0	160.1	.823 (2.70)	.22	9.90	10.37	.35	-.47	.39
10	135,987 (299,800)	167.6	162.8	1.103 (3.62)	-1.93	9.51	10.24	.14	2.15	.27
11	136,123 (300,100)	175.2	170.1	1.219 (4.00)	2.36	9.08	9.85	2.02	-1.45	.52
13	136,168 (300,200)	179.1	173.9	.455 (1.49)	-1.64	9.16	9.44	2.72	-.24	-----
14	131,043 (288,900)	180.0	178.2	1.150 (3.77)	1.95	7.72	8.44	1.67	-----	.92
16	131,451 (289,800)	174.7	172.6	1.100 (3.61)	.73	8.33	9.03	.07	-.11	.35
17	138,482 (305,300)	191.7	184.6	.744 (2.44)	-.02	8.41	8.84	-.03	-.53	-----
18	132,676 (292,500)	183.4	180.4	1.018 (3.34)	.54	7.99	8.61	1.16	-1.33	-.10
19	130,907 (288,600)	182.2	180.4	1.219 (4.00)	-.03	8.36	9.11	-.09	2.48	.08
20	132,222 (291,500)	182.5	179.8	1.088 (3.57)	-.43	7.91	8.58	-.05	.48	.35
21	135,624 (299,000)	190.0	184.8	.491 (1.61)	.10	8.36	8.64	.04	-.44	-.74
22	132,313 (291,700)	-----	-----	1.268 (4.16)	-----	----	-----	-----	-----	-----
23	133,810 (295,000)	173.9	170.3	1.052 (3.45)	-.13	9.18	9.85	.14	-.54	.22
24	131,270 (289,400)	179.5	174.8	1.170 (3.84)	-.81	7.98	8.71	-.49	-.73	-.03
25	132,131 (291,300)	175.7	173.2	.847 (2.78)	.55	8.17	8.70	-1.16	-.34	-.69
26	146,692 (323,400)	190.4	178.1	.924 (3.03)	-2.10	8.82	9.35	-.79	-.99	-.82
27	130,090 (286,800)	-----	-----	.872 (2.86)	-----	----	-----	-----	-----	-----
28	131,270 (289,400)	180.0	178.0	1.295 (4.25)	0	8.00	8.80	-.14	-.17	.09
29	142,836 (314,900)	180.0	170.6	.634 (2.08)	-2.15	9.56	9.96	1.64	-.36	.01
30	130,544 (287,800)	-----	-----	.802 (2.63)	-----	----	-----	-----	-----	-----
31	130,090 (286,800)	-----	-----	1.487 (4.88)	-----	----	-----	-----	-----	-----
32	169,870 (374,500)	193.4	168.1	1.603 (5.26)	-.52	9.67	10.59	1.04	-.48	.51
33	130,090 (286,800)	180.4	179.2	.725 (2.38)	-1.07	8.39	8.84	.47	0	-.16
34	146,510 (323,000)	-----	-----	1.387 (4.55)	-----	----	-----	-----	-----	-----
38	146,737 (323,500)	-----	-----	----- ----	-1.97	----	-----	-----	-3.28	-.46
39	129,909 (286,400)	185.5	184.4	----- ----	-2.03	----	9.29	-.20	-.13	.19
40	127,777 (281,700)	173.6	174.0	----- ----	-.38	----	9.74	-.80	-.66	-.60
41	126,235 (278,300)	175.3	176.8	----- ----	1.95	----	8.91	.59	-1.64	0
42	131,088 (289,000)	174.9	173.1	----- ----	-.53	----	9.35	1.12	-.36	-.75
43	130,725 (288,200)	176.2	174.6	----- ----	.64	----	9.44	.17	-2.36	.40
44	130,453 (287,600)	182.3	180.8	----- ----	2.98	----	7.42	.32	-1.88	-.15
45	130,317 (287,300)	179.2	177.9	----- ----	.02	----	10.19	.65	.41	-.38
46	128,185 (282,600)	184.0	184.1	----- ----	-2.01	----	8.52	.36	-.72	.21
47	134,626 (296,800)	172.1	168.1	----- ----	-.26	----	9.49	.80	1.82	.17
48	151,454 (333,900)	178.1	164.0	----- ----	-.21	----	10.27	.84	-.63	-.94

[1] Flights 6, 8, 12, 15, and 35 to 37 omitted because of insufficient data.

TABLE I. - VALUES OF LANDING-CONTACT CONDITIONS AND OTHER PERTINENT DATA FOR LANDINGS OF THE XB-70 AIRPLANES - Concluded

[XB-70-2]

Flight (1)	Landing weight, kg (lb)	Measured indicated airspeed, knots	Adjusted airspeed, knots	Angle of roll, deg	Angle of attack, deg	Angle of sideslip, deg	Rolling velocity, deg/sec	Pitching velocity, deg/sec
1	133,810 (295,000)	154.9	151.7	2.1	----	----	1.80	-----
10	129.818 (286.200)	157.5	156.6	3.5	6.2	-0.4	1.80	-----
11	129.092 (284.600)	169.9	169.4	1.7	9.0	0	-----	-0.38
12	131.905 (290.800)	169.1	166.8	-.2	9.1	1.8	-.20	-.02
13	128.548 (283.400)	166.7	166.6	-1.2	5.8	1.0	-1.10	-.02
14	132,812 (292.800)	163.7	160.9	1.3	7.9	-.3	.33	-.02
16	133.492 (294.300)	174.2	170.8	1.1	8.3	-1.9	1.55	-.58
17	132.177 (291.400)	165.3	162.9	1.1	8.8	1.1	.21	0
18	129,727 (286.000)	173.8	172.9	-.1	7.9	1.2	.78	-.20
20	137.348 (302.800)	169.2	163.6	.4	9.7	.4	.20	-.07
21	128.007 (282.200)	155.3	155.5	2.2	9.6	.1	0	.10
22	133,719 (294,800)	162.2	158.9	2.1	9.8	1.0	0	0
23	135.307 (298.300)	174.5	170.0	-.2	9.9	0	-.70	-----
24	129.092 (284.600)	179.7	179.2	-.9	8.6	-.4	-.60	-.09
25	130.589 (287.900)	168.8	167.4	2.0	9.5	.3	-.24	-.04
29	130.453 (287.600)	180.0	178.6	1.6	7.4	-.2	.90	-.31
30	127.414 (280.900)	174.4	175.1	-2.6	8.1	0	.09	.68
31	129.138 (284.700)	165.2	164.7	1.3	8.8	3.2	4.80	.09
32	133.764 (294.900)	168.0	164.6	1.6	9.2	-.8	.55	.26
33	134.672 (296.900)	173.9	169.8	3.9	8.8	.8	3.90	.14
34	134.263 (296.000)	168.2	164.4	-1.4	10.2	-.5	-----	.49
35	129.954 (286.500)	176.2	175.1	.8	9.1	-.4	-----	.55
37	141.566 (312.100)	174.8	166.5	2.2	8.6	-.1	.59	-.18
38	127.958 (282.100)	186.7	187.0	1.7	8.1	-4.2	2.00	.65
39	127.233 (280.500)	161.4	162.1	3.3	8.6	1.8	-.50	-.56
40	133.265 (293.800)	165.4	162.3	-1.2	8.1	.4	-.57	-----
41	128.230 (282.700)	177.4	177.5	3.1	7.9	-1.2	-----	.47
42	128.503 (283.300)	179.6	179.5	-1.9	8.7	0	-.02	.67
44	125.871 (277.500)	170.2	171.9	2.1	8.1	.9	-2.60	.11
45	129.092 (284.600)	169.3	168.8	1.4	8.5	-1.4	-.20	-.91

[1] Flights 2 to 9, 15, 19, 26 to 28, 36, and 43 omitted because of insufficient data.

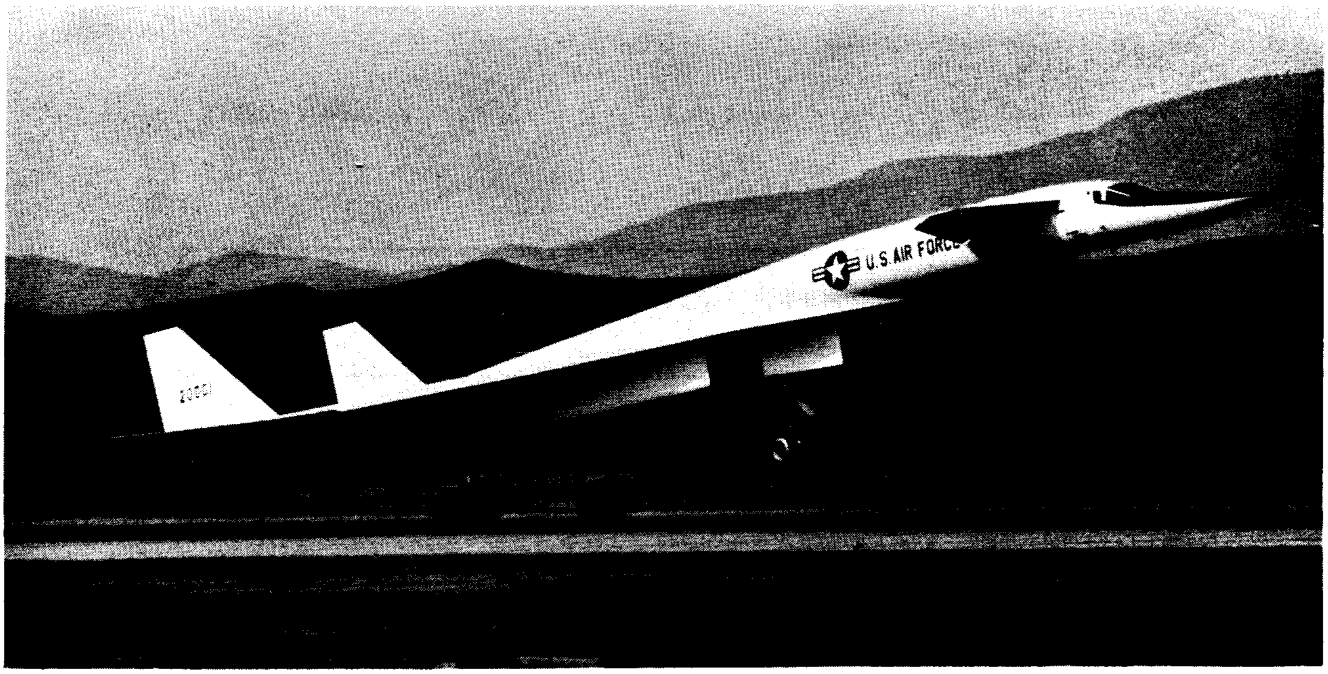

Figure 1.– XB-70 airplane.

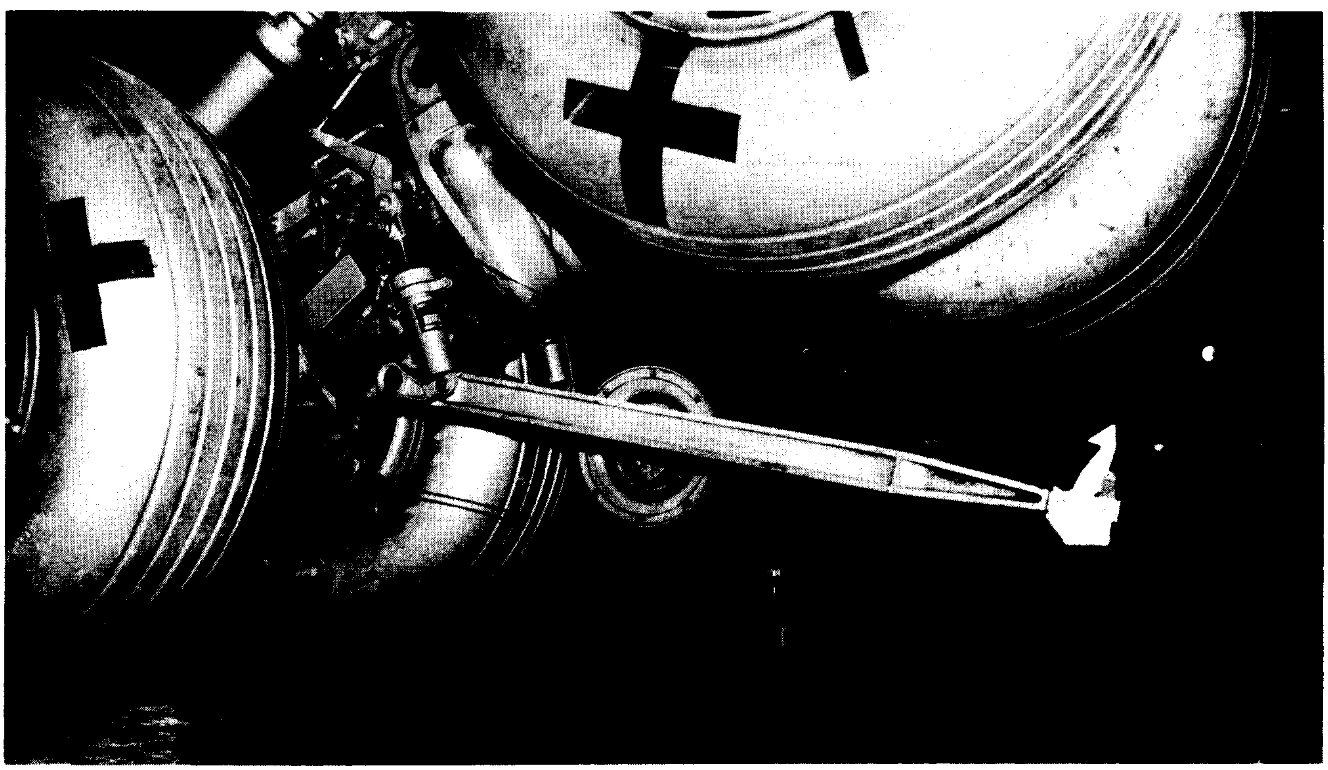

Figure 2.– Vertical-velocity trailing arm.

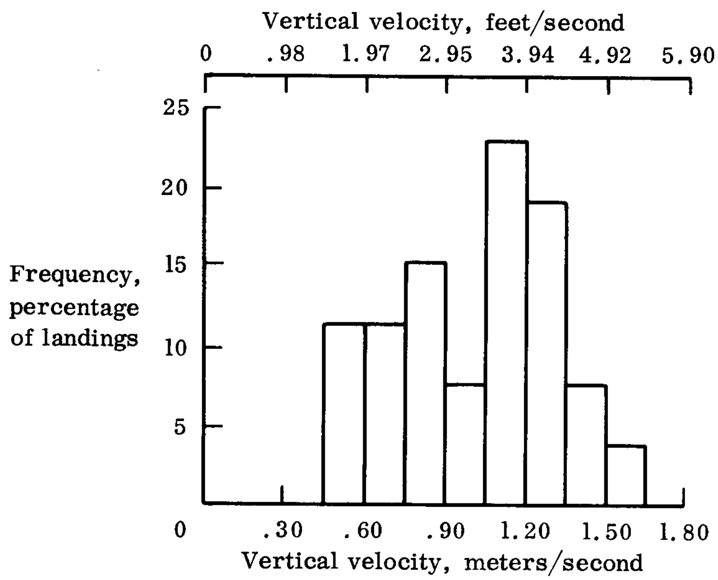

Figure 3.– Frequency histogram of vertical velocity at contact for the XB-70-1. 26 landings.

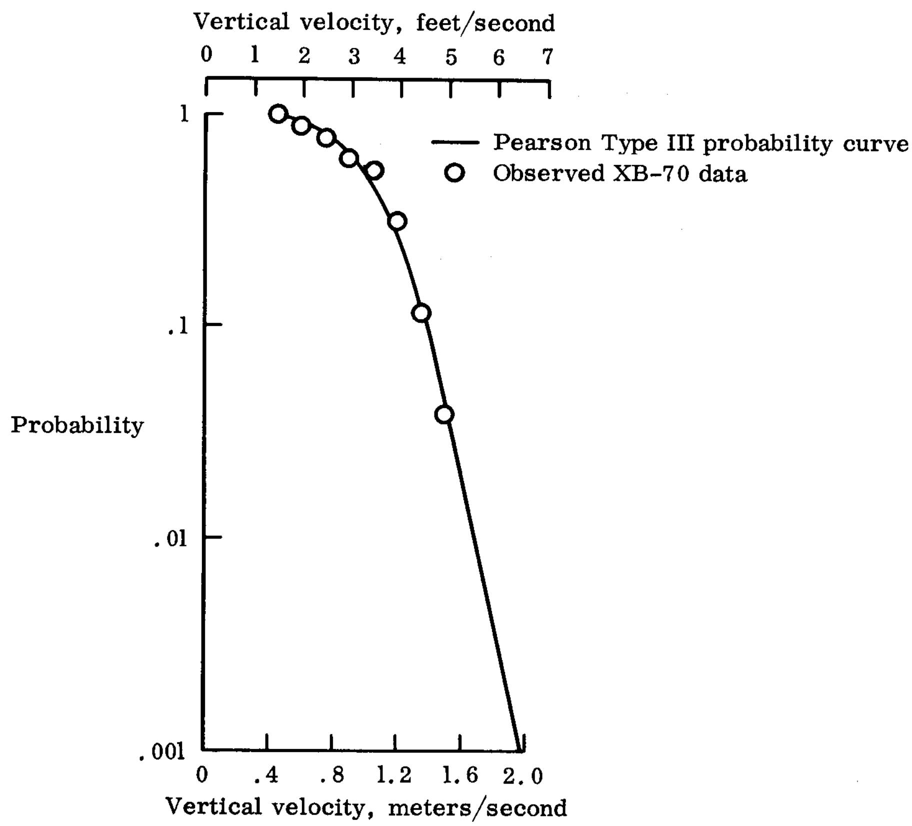

Figure 4.– Probability of equaling or exceeding various values of vertical velocity for the XB-70-1. 26 landings.

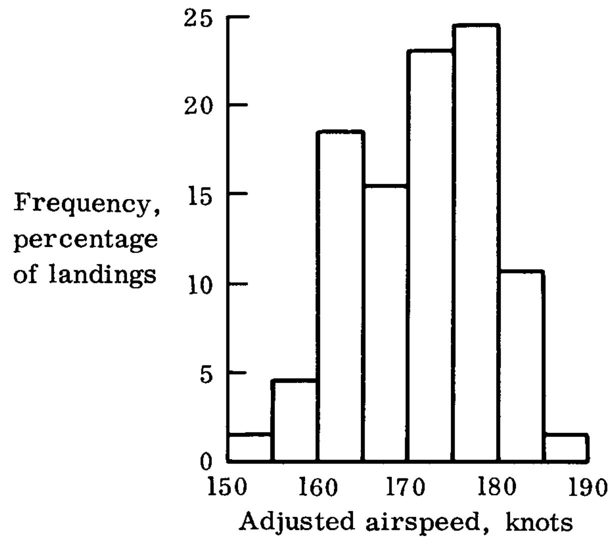

Figure 5.— Frequency histogram of the adjusted airspeed at contact for the XB-70 airplanes. 65 landings.

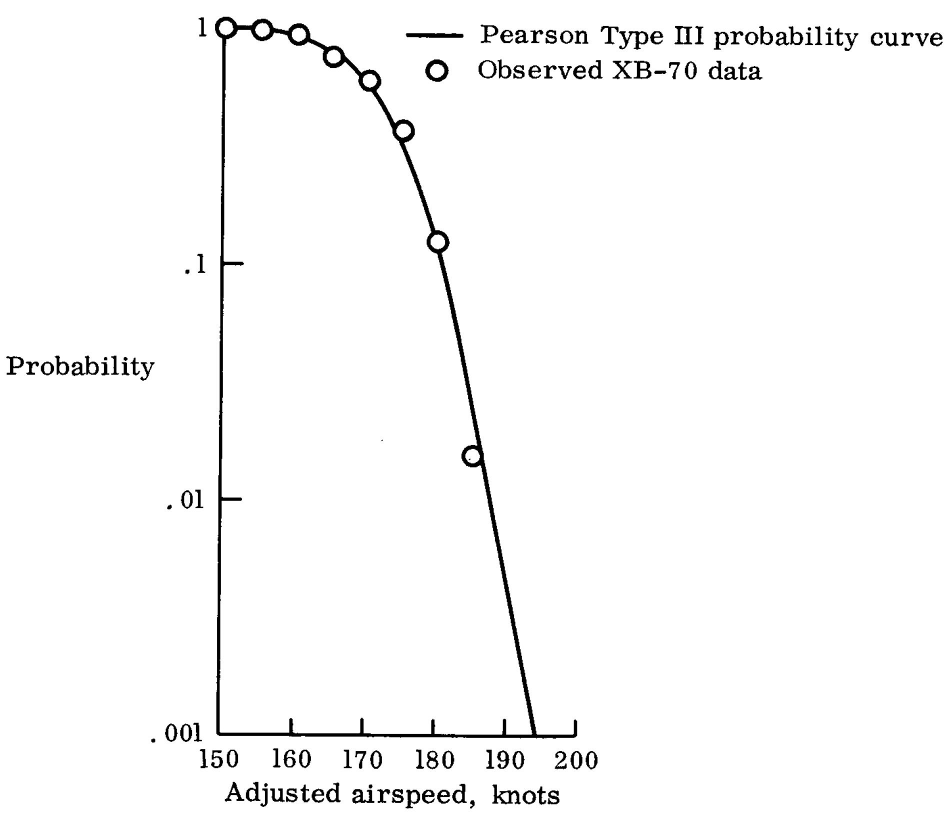

Figure 6.— Probability of equaling or exceeding various values of adjusted airspeed at contact for the XB-70 airplanes. 65 landings.

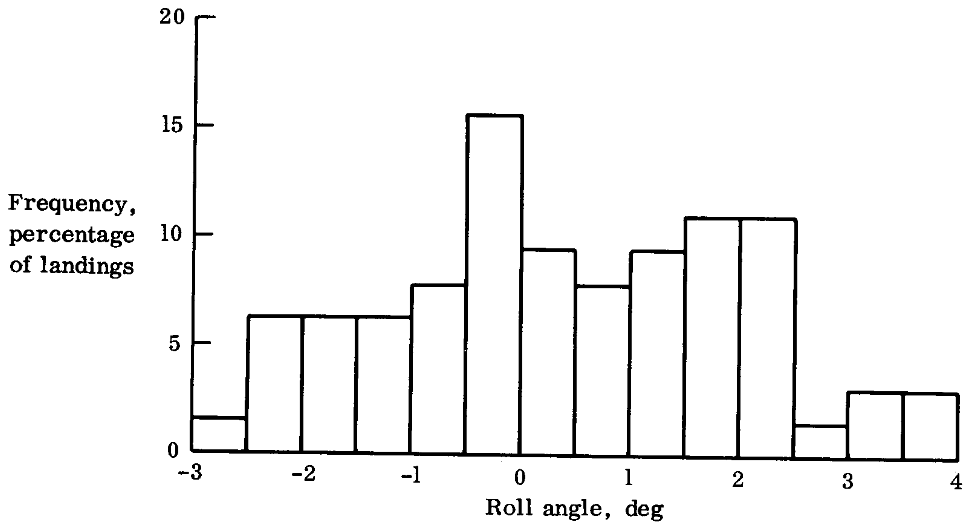

Figure 7.— Frequency histogram of roll angle at contact for the XB-70 airplanes. 64 landings.

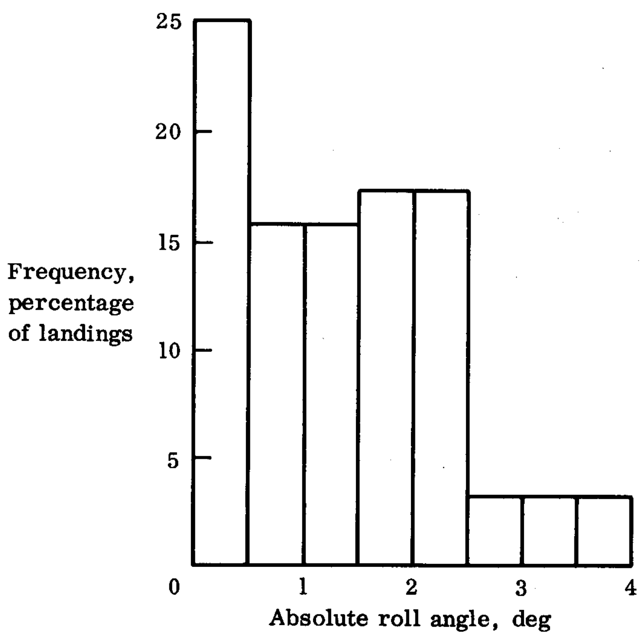

Figure 8.— Frequency histogram of the absolute roll angle at contact for the XB-70 airplanes. 64 landings.

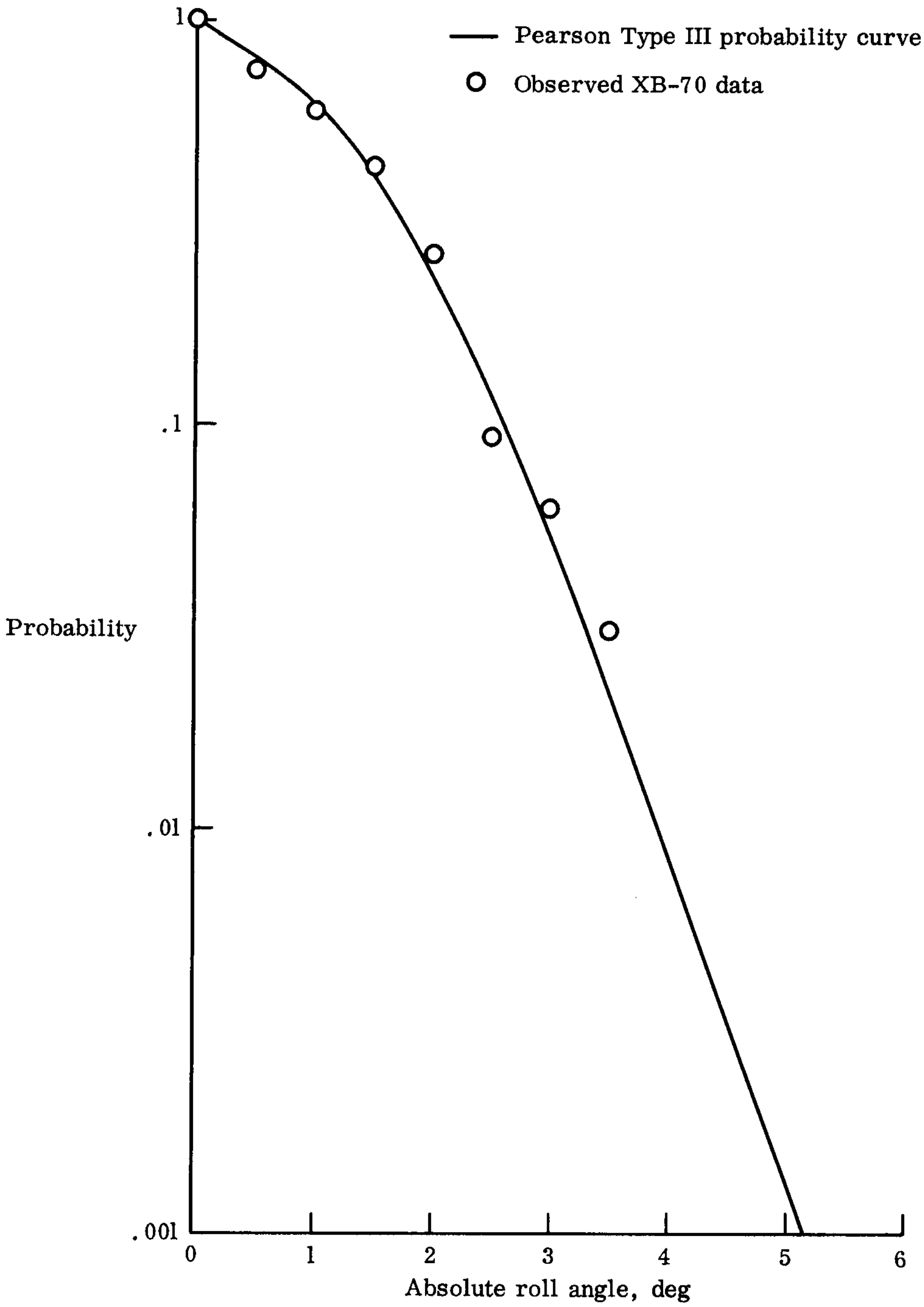

Figure 9.– Probability of equaling or exceeding various values of absolute roll angle during landing contact for the XB-70 airplanes. 64 landings.

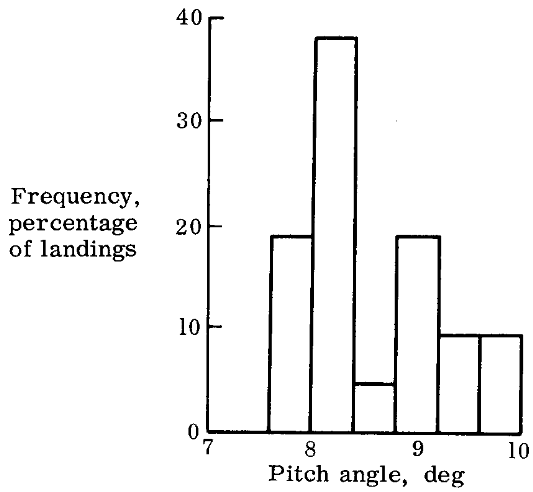

Figure 10.— Frequency histogram of pitch angle at contact for the XB-70-1. 21 landings.

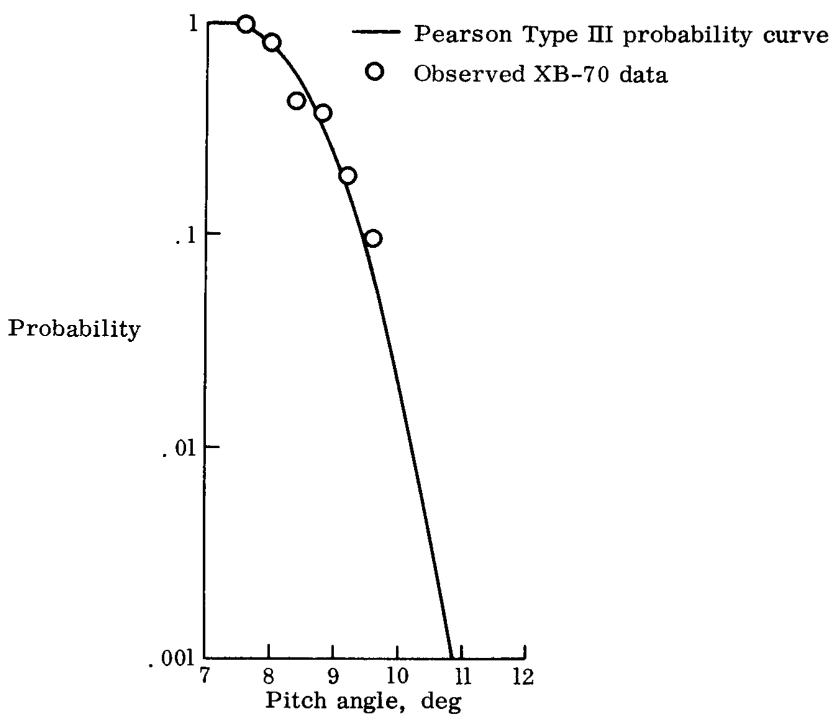

Figure 11.— Probability of equaling or exceeding various values of pitch angle during landing contact for the XB-70-1. 21 landings.

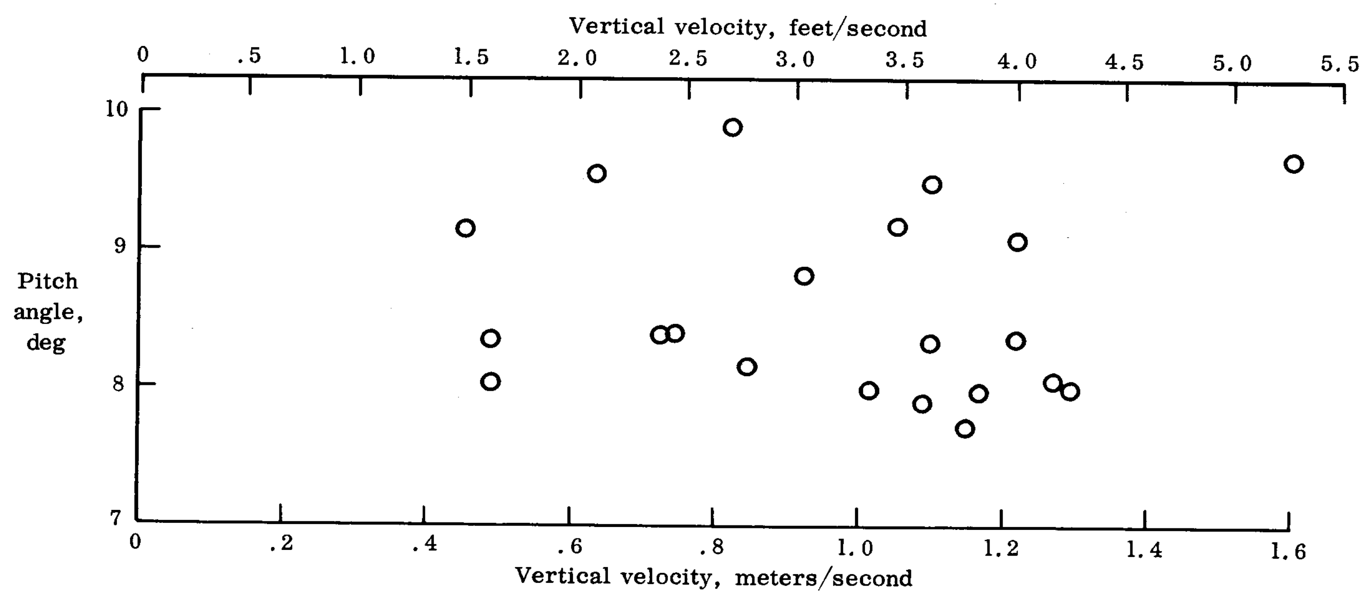

Figure 12.— Variation of vertical velocity with pitch angle at contact for the XB-70-1. 21 landings.

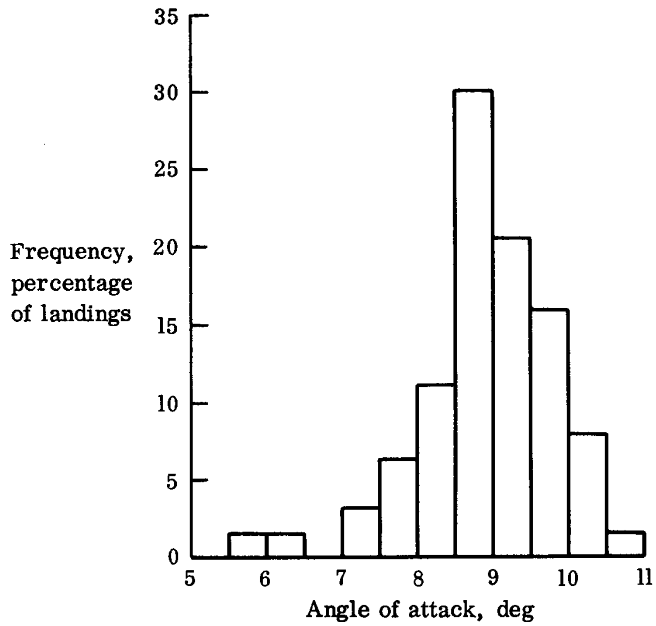

Figure 13.— Frequency histogram for angle of attack at contact for the XB-70 airplanes. 63 landings.

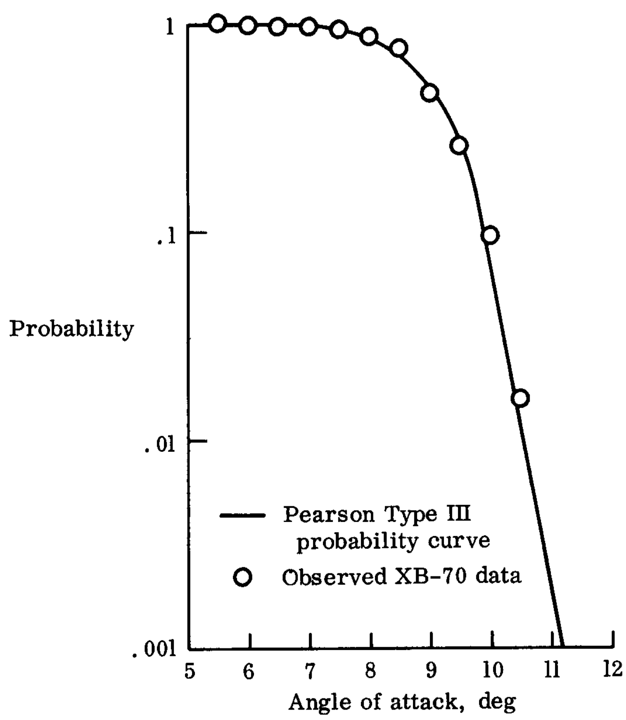

Figure 14.— Probability of equaling or exceeding various values of angle of attack during landing contact for the XB-70 airplanes. 63 landings.

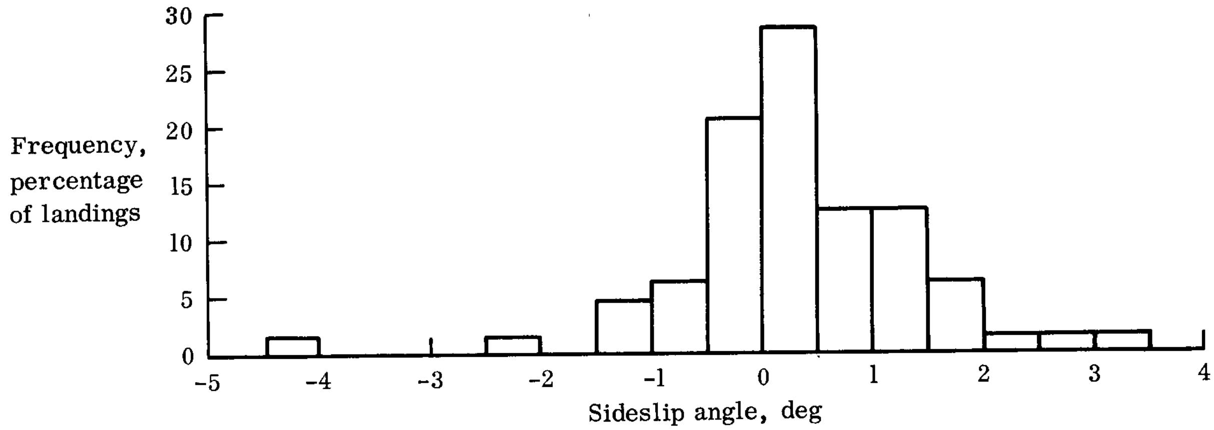

Figure 15.— Frequency histogram of sideslip angle at contact for the XB-70 airplanes. 63 landings.

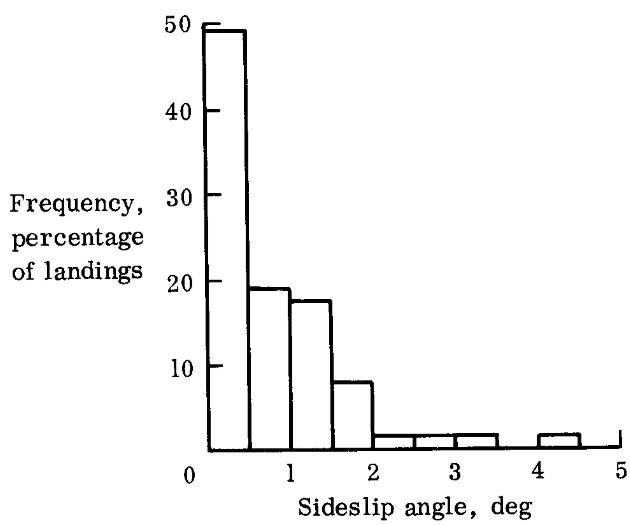

Figure 16.— Frequency histogram of absolute sideslip angle at contact for the XB-70 airplanes. 63 landings.

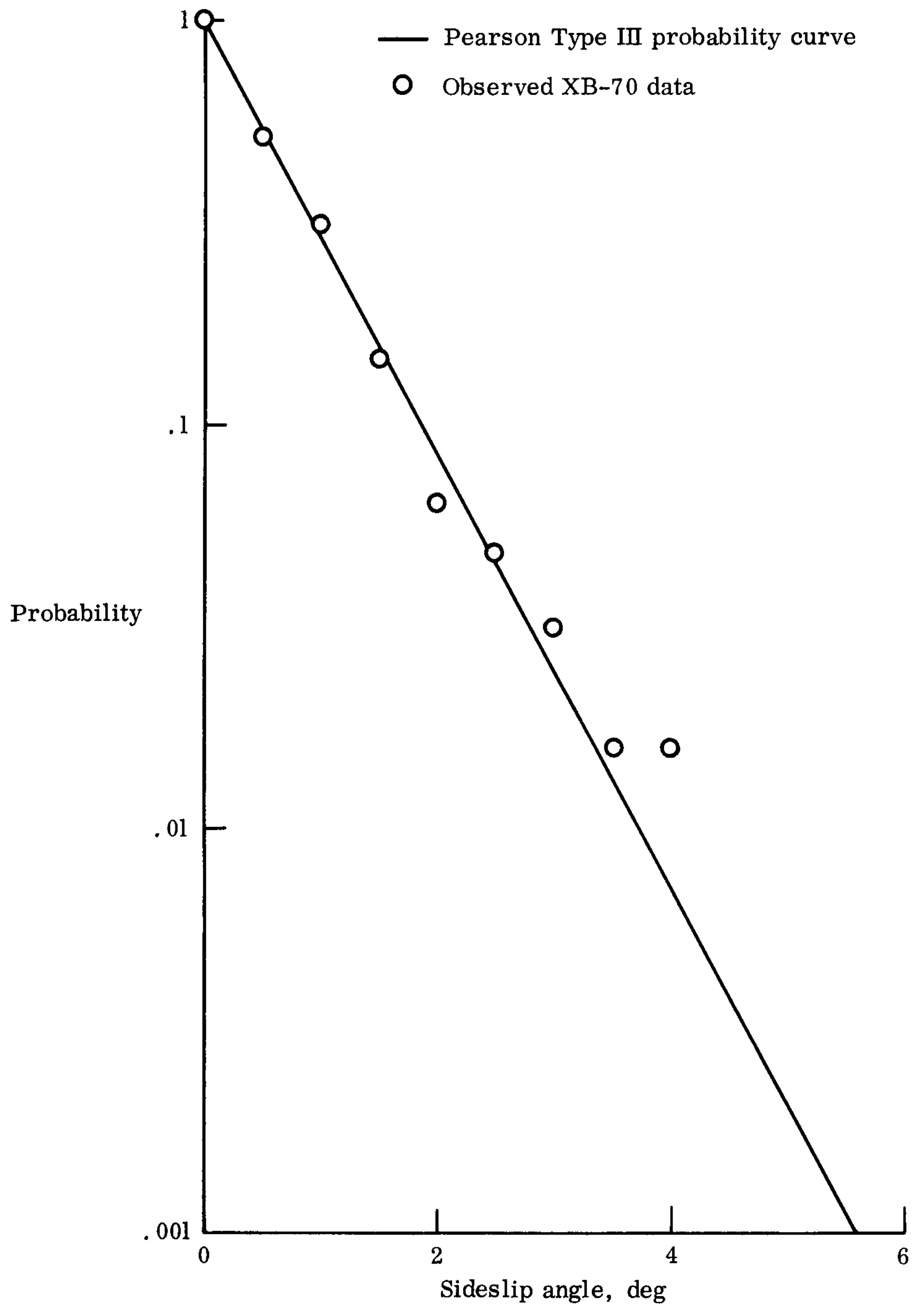

Figure 17.– Probability of equaling or exceeding various values of absolute sideslip angle during landing contact for the XB-70 airplanes. 63 landings.

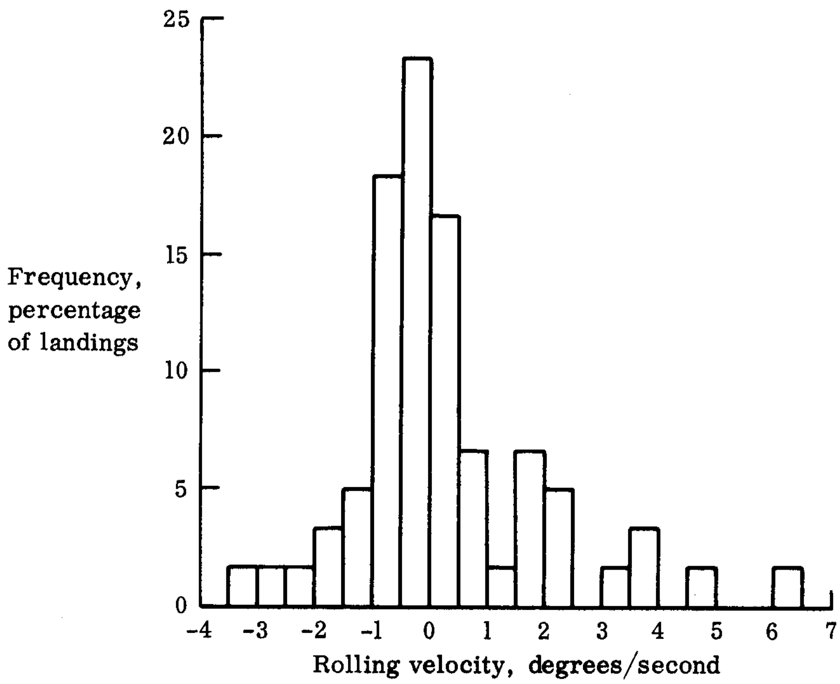

Figure 18.– Frequency histogram of rolling velocity at contact for the XB-70 airplanes. 60 landings.

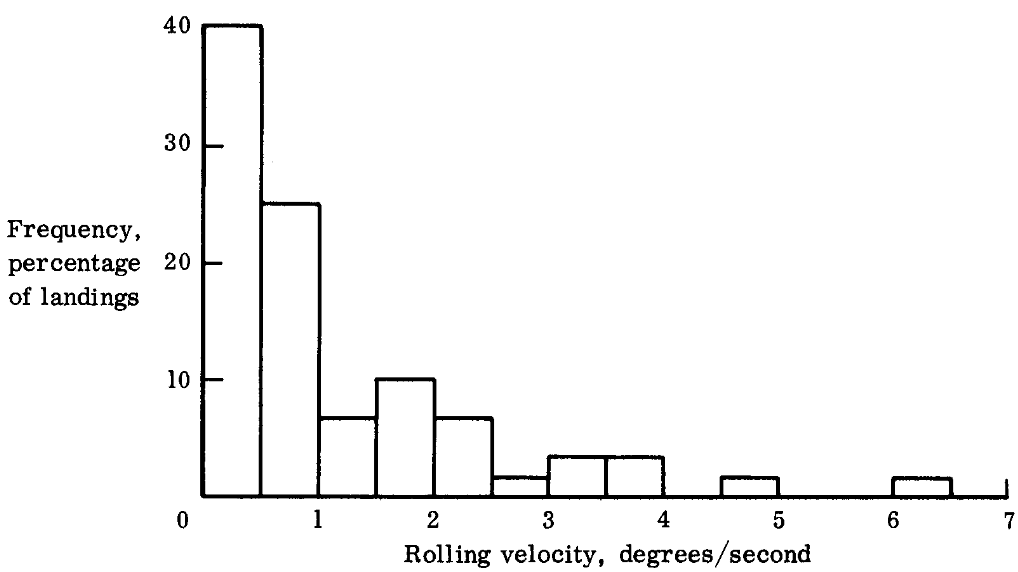

Figure 19.– Frequency histogram of the absolute rolling velocity at contact for the XB-70 airplanes. 60 landings.

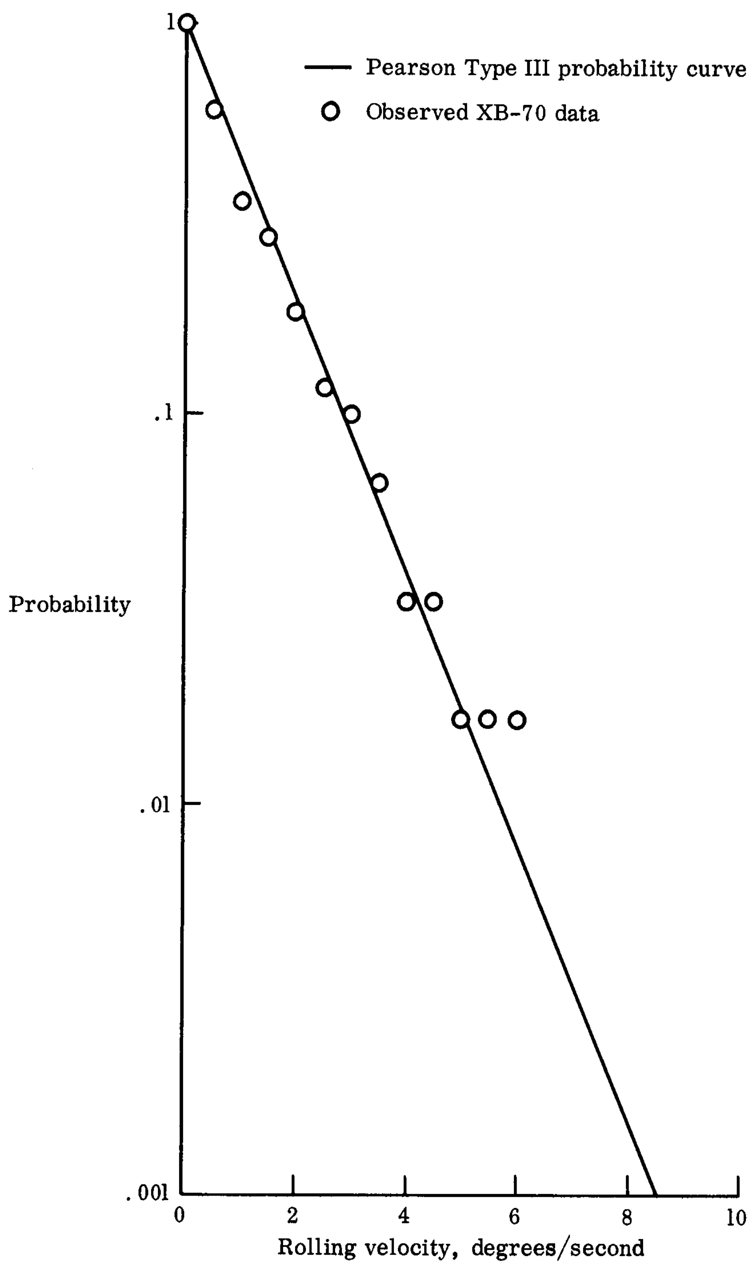

Figure 20.– Probability of equaling or exceeding various values of absolute rolling velocity during landing contact for the XB-70 airplanes. 60 landings.

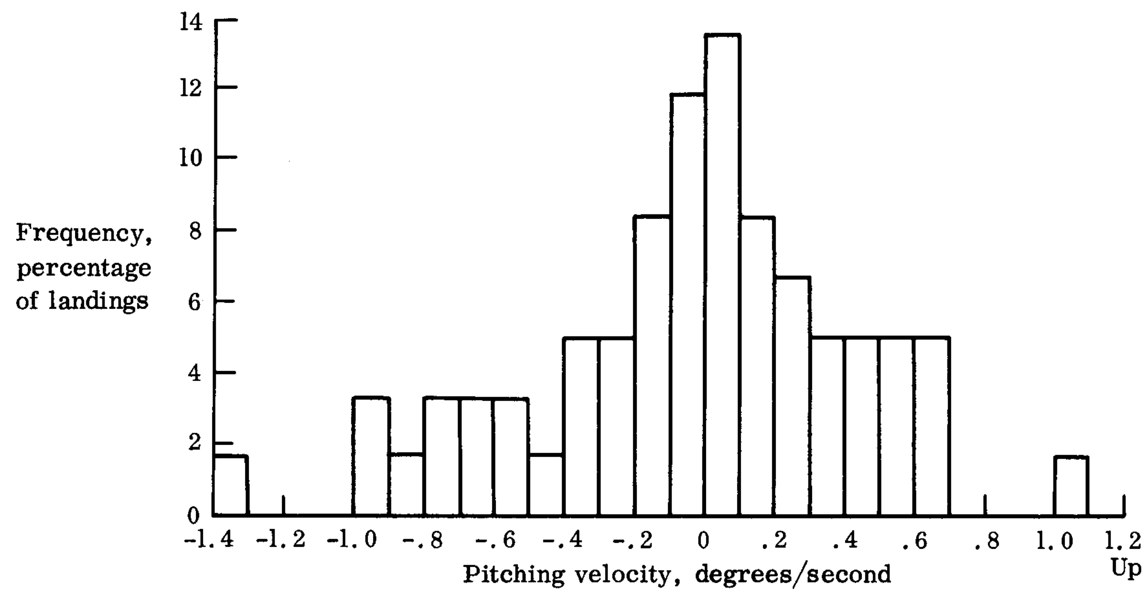

Figure 21.– Frequency histogram of pitching velocity at contact for the XB-70 airplanes. 59 landings.

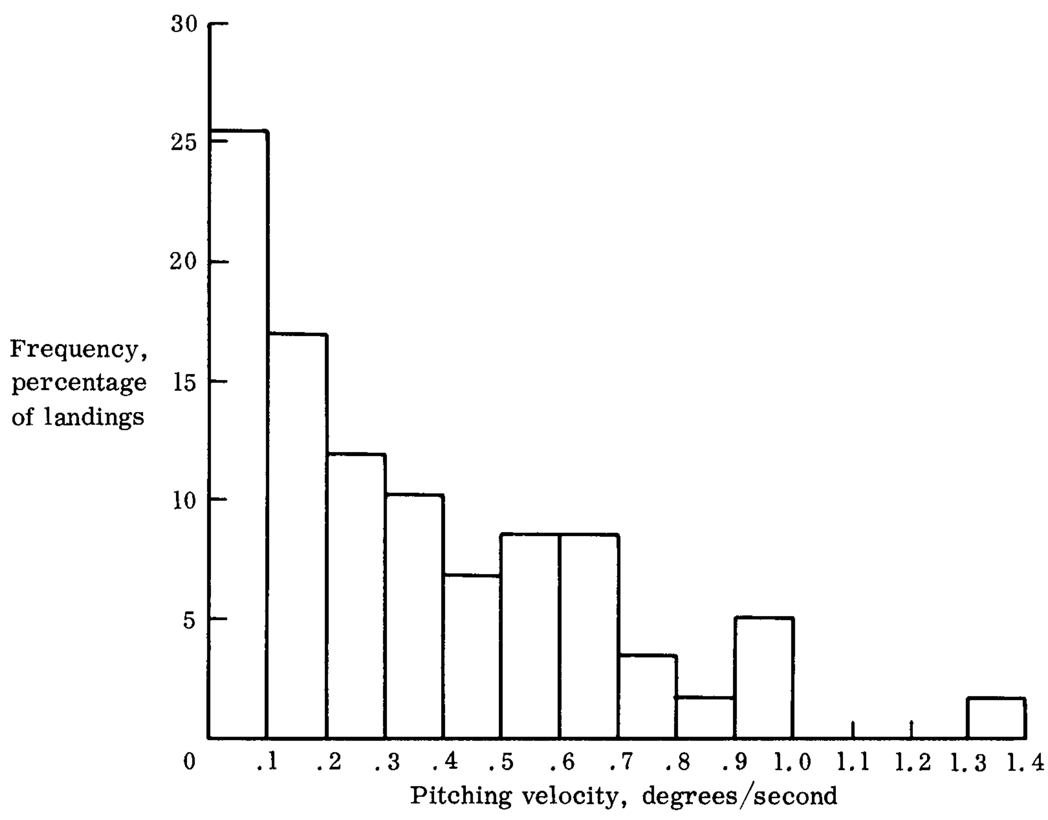

Figure 22.– Frequency histogram of the absolute pitching velocity at contact for the XB-70 airplanes. 59 landings.

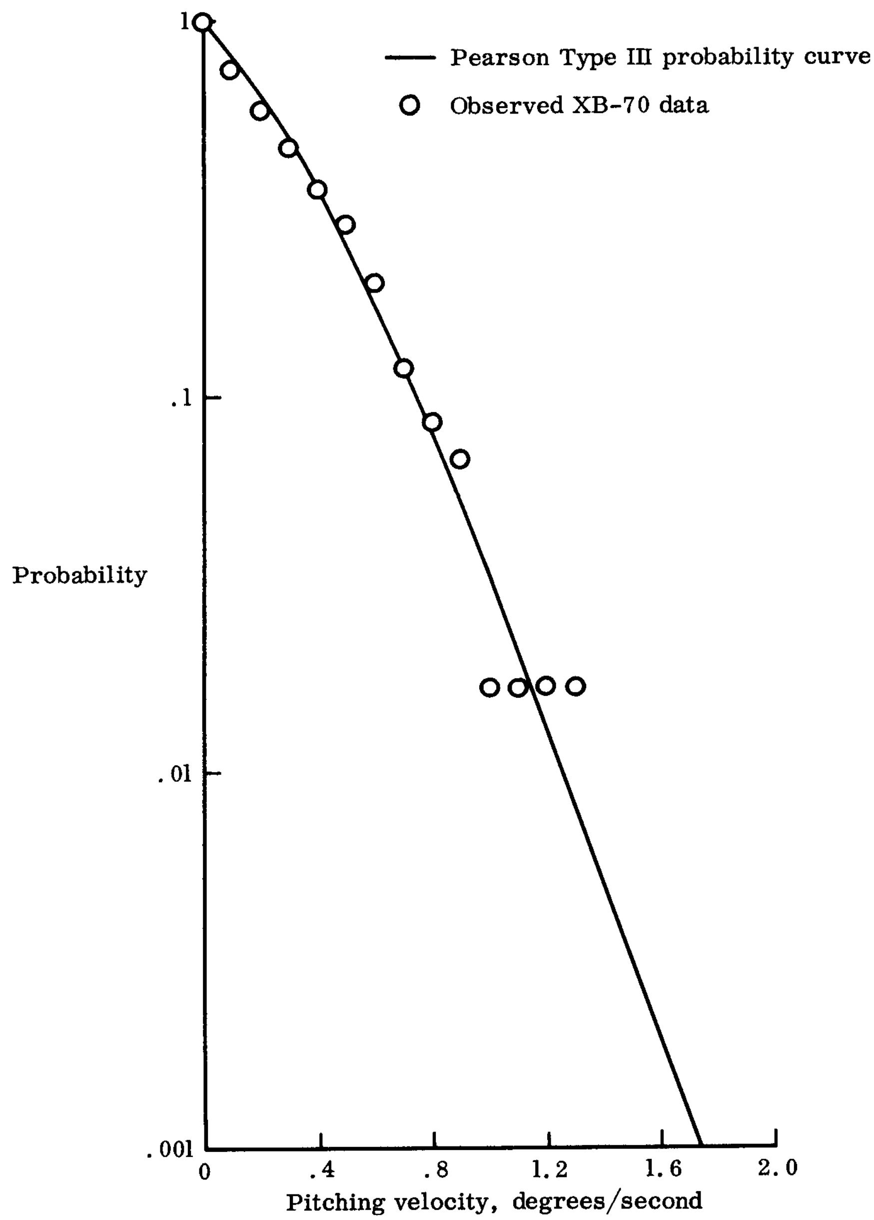

Figure 23.– Probability of equaling or exceeding various values of absolute pitching velocity during landing contact for the XB-70 airplanes. 59 landings.